2018-06-11

Structural & Stratigraphic Evolution of the Rio Del Rey Basin (Cameroon) - Field Development & New Exploration Potential

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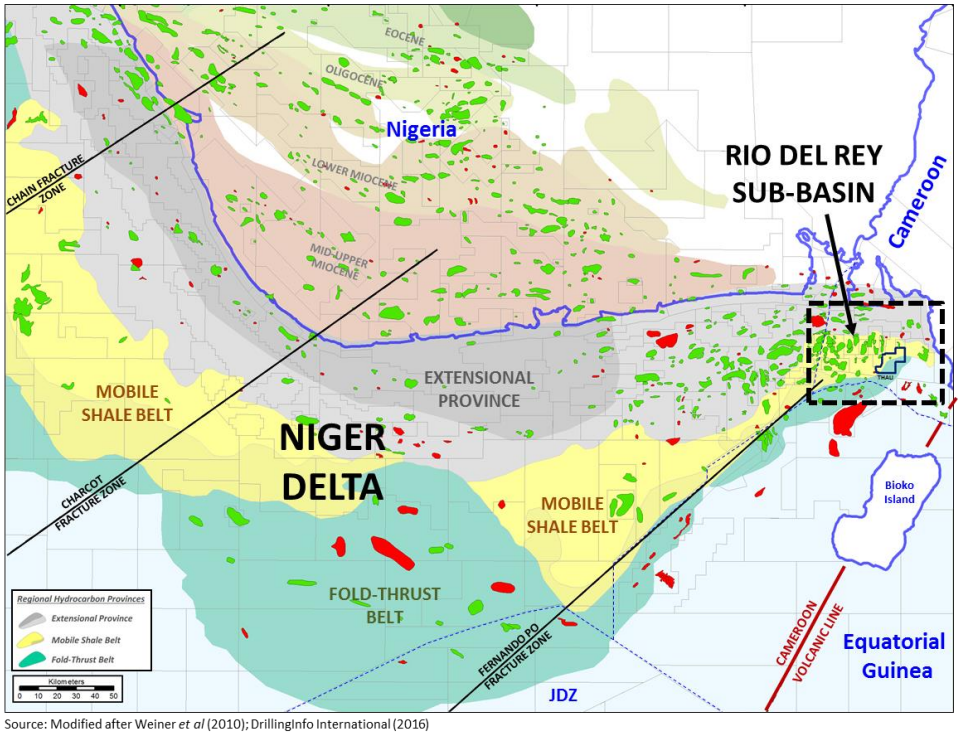
10.3997/2214-4609.201801151
Proceedings
EAGE Publications BV

Introduction

We present a new analysis of the Rio del Rey sub-basin of Niger Delta (offshore Cameroon), where analysis of legacy seismic and well data have been integrated using a play based exploration approach in order to evaluate the remaining potential in the basin. The Thali block has an exploration history extending back to the 1970's with three discoveries in shallow prospects. However, poor understanding of reservoir, charge and cross-fault seals has resulted in unpredicted results and no field development to date.

We demonstrate how improved understanding of the complex interrelationship between evolving deepwater gravitational structures and stratigraphy, incorporating newly reprocessed seismic, has been applied to produce a new development plan for the Thali block and expose significant new exploration potential in deeper plays, which are prolific elsewhere in the region.



Source: Modified after Weiner *et al* (2010); DrillingInfo International (2016)

Figure 1 *The Niger Delta showing distribution of the major structural zones and other key elements. Note also the distribution of hydrocarbon fields within the different structural zones.*

The Rio del Rey Basin

The Rio del Rey Basin is a mature hydrocarbon province occupying the eastern portion of the greater Niger Delta system (Figure 1). Fields in the basin have been on production since the 1970's and over a billion barrels of oil has been produced to date. However, until recently, little has been done to explore for plays beyond the prolific Late Miocene to Pleistocene shallow water deltaics. Since the Eocene, the Niger Delta has prograded in an unconfined manner into the Atlantic Ocean basin. The lack of confinement has meant that the gravitational deformation system and, specifically, the compressional zones of that system, are broad zones with multiple discrete structures. The situation is very different in the Rio del Rey area where the eastern Niger Delta prograded in a south/south-easterly direction, at the same time as the emplacement of the Cameroon Volcanic Line (CVL) system. This volcanic system essentially bisected the basin separating the Douala Basin in the east

from the Rio del Rey to the west. In the Rio del Rey this created an uplifted zone, with a very narrow contractional zone and funnelling of the sediment fairways on the western side of the uplifted CVL.

Setting of Petroleum Plays

Through an integrated study of public domain and proprietary datasets, a complete stratigraphic scheme has been developed for the Rio del Rey basin along with a more detailed chronostratigraphy for the Thali area. The distribution and lithologies of Oligocene and older stratigraphic units in the Rio del Rey basin are poorly understood due to the lack of deep well penetrations offshore as well as significant uplift and erosion in the onshore part of the basin. It is known regionally that the rocks of these ages are some of the most prolific source rocks in the basin (Tuttle et al., 1999) and evidence from deep, long offset seismic data also suggests that these strata can form the main detachment zones for the gravitational deformation system. The stratigraphy of the Miocene and younger section is better understood due to the numerous well penetrations in the offshore. Throughout the Miocene and Pliocene deposition occurred at the same time as the development of the compressional part of the gravitational system of the Niger Delta, with deposits ponded around the flanks of structural highs and within bathymetric lows associated with collapse of the palaeo-Niger delta front. Based on regional correlations a schematic stratigraphy and a series of palaeogeography maps have been developed for the basin from Late Cretaceous to Recent times which highlight the importance of the development of the main structural features on the sediment distribution patterns.

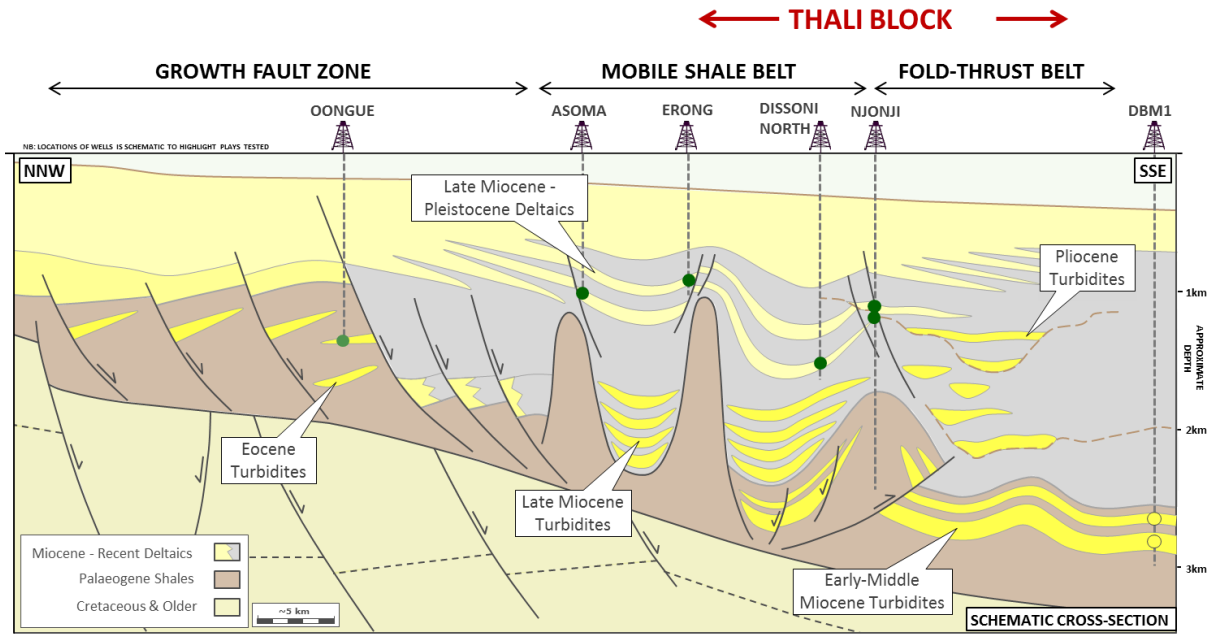


Figure 2 *Petroleum plays and structural styles of the eastern Niger Delta, showing the setting of the Thali Block. Sandstone plays exist in (i) pre-folding Early-Middle Miocene 'Isongo' turbidites; (ii) Late Miocene ponded mini-basin plays; (iii) Pliocene syn-fold turbidite channel systems; and (iv) crestal Plio-Pleistocene distal delta front fault-bounded plays. To date, discoveries have been made in these shallow plays. Deeper plays have not been tested, but are successful plays in the region (e.g. Alba Field, Zafiro Field).*

Exploration drilling in the Rio del Rey of Cameroon demonstrates the presence of two regional play fairways: (i) Early - Middle Miocene Isongo slope and basin floor turbidites; and (ii) Late Miocene to Pleistocene delta front plays. The Isongo turbidites, which are the main reservoir in the giant Alba Field in Equatorial Guinea (Wolak & Gardner, 2009) and in the Etinde discoveries in Cameroon, exhibit a distinctive seismic facies. This allows correlations of the play fairway both regionally and within the Thali area, where the turbidites are present within structural closures and also within more

complicated structural-stratigraphic traps. As in the shallow water GOM during the early 1990's, the utilisation of modern play based exploration concepts and technology is likely to unlock significant additional resource within this play in more subtle stratigraphic traps

Development of Existing Discoveries

The younger delta front plays have produced more than 1 billion barrels of oil in the basin to date, almost entirely from shallow (<1500m) reservoirs trapped in fault block closures over the crests of highs. Three discoveries have been made in the block. Detailed interpretation of reprocessed data has identified and delineated multiple additional shallow fault block prospects (Figure 3) which have been evaluated as part of the development plan for this Block. Understanding cross-fault seals and charge are critical to the development planning.

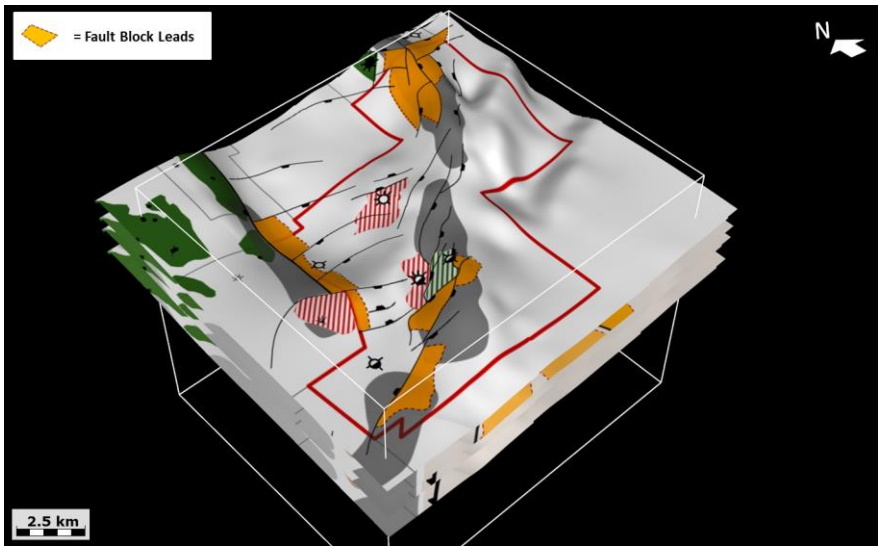


Figure 3 *Plio-Pleistocene discoveries and new prospects are present in normal fault blocks in crestal positions above a series of en-echelon NE-SW trending anticline structures (grey polygons).*

New Play: Pliocene Syn-fold Deepwater Slope Channel Systems

In addition to the Isongo and shallow deltaic plays, a new Pliocene turbidite channel play has been identified within the Thali area through integrated seismic stratigraphic and amplitude mapping techniques (Figure 4). It is proposed that a series of collapses of the palaeo-Niger delta front during the Late Miocene and Pliocene resulted in the re-working of shallow marine sands into a deeper water setting. These sands were deposited in a series of NE-SW orientated, sinuous turbidite channel systems which developed along the eastern flank of growth-folds. These channel systems developed during the late stages of the SW emplacement of the marginal thrust-propagation folds. The channel-levee systems developed in structurally controlled topographic lows along the flanks of these folds, gradually on-lapped the flanks of these structures and were progressively titled as contractional deformation died out. Reservoir unit distribution is influenced by gravitational normal faults caused by partial collapse of the anticline flanks. In the late stages of evolution of the play, lateral strictures between en echelon fold elements can also be demonstrated to control reservoir distribution.

This play is undrilled in Cameroon, but analogous giant fields (i.e. Zafiro, Edop) have been discovered in equivalent reservoirs across the border in Equatorial Guinea (Ardill et al., 2005) and Nigeria and this play has been the focus of exploration in Equatorial Guinea where recent drilling has extended the proven play fairway towards Cameroon.

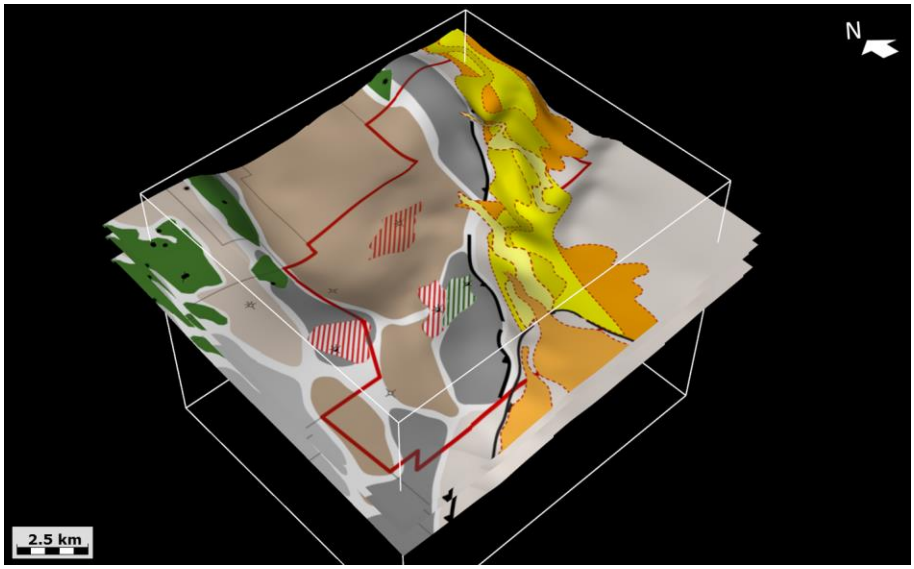


Figure 4 *Yellow and orange polygons show extent of stacked SW flowing turbidite channel systems which were structurally confined by, and onlap, the eastern margin of coeval thrust propagation folds (grey polygons). Late stage channels show some cross-fold bypassing through lateral ramps.*

Conclusions

The application of an integrated play fairway methodology, seismic stratigraphic and modern visualisation techniques has improved the delineation of the extents and potential of different play fairways in the Thali block. This work has led to a new development plan for existing crestal discoveries. This work has also identified the presence of a series of untested syn-folding and pre-folding turbidite plays and prospects which have analogues in large discoveries in other parts of the greater Niger Delta system. Development and exploration strategies are dependant understanding the interplay between syn-sedimentary gravitational structures, turbidite reservoir distribution, trap-forming mechanisms and charge prediction.

Acknowledgements

We thank Tower Resources plc for permission to share this work.

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